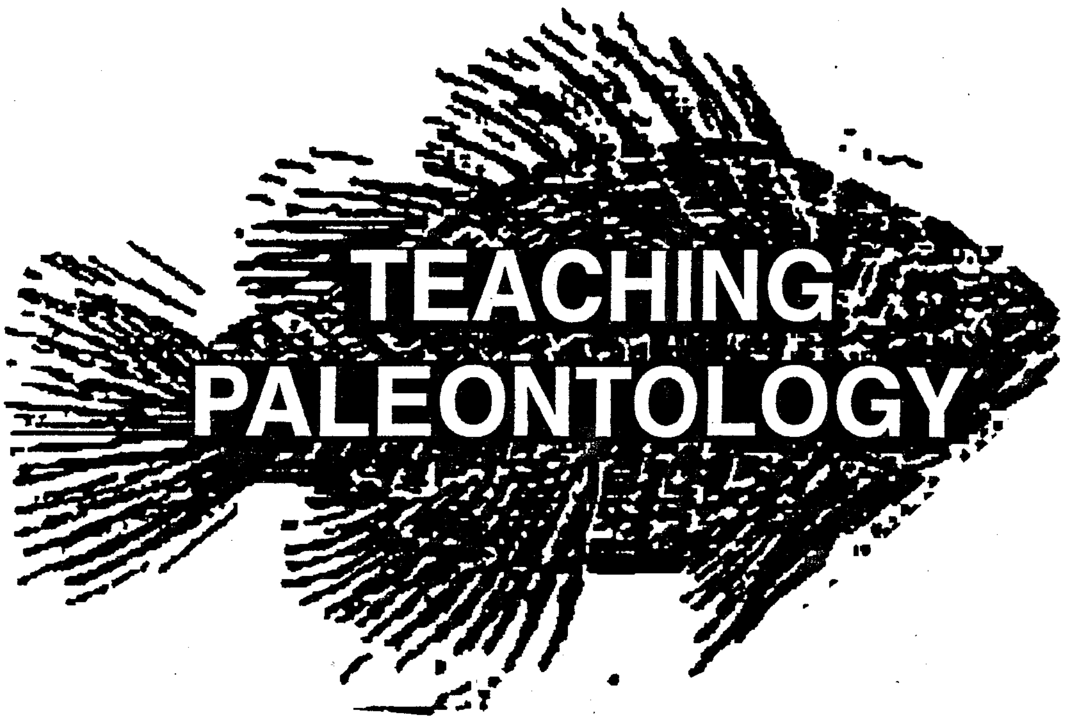

TEACHING PALEONTOLOGY IN THE NATIONAL PARKS AND MONUMENTS AND PUBLIC LANDS

NATIONAL PARK SERVICE

A Curriculum Guide for Teachers of the Second and Third Grade Levels

Teaching Paleontology in the National Parks And Monuments and Public Lands

A Curriculum Guide for Teachers of the Second and Third Grade Levels

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Forward

This curriculum guide for paleontology was developed by Fossil Butte National Monument as part of its growing environmental education program. It is designed to be used by teachers as an aid in presenting principles of fossils and past life to students in the second and third grades.

Paleontology involves the integration of a number of different areas of expertise. We hope these exercises will help teachers to encourage the various talents their students have to offer. While only a minority of students may feel a calling to become scientists, those who do not will, with luck, be stimulated by the cultural or artistic aspects of paleontology, and perhaps better identify with scientists in general. The primary message of these units should be that science is fun.

The concepts of ancient life and geologic time are the focus of paleontology. These are difficult concepts for anyone to understand, especially children. The study of paleontology including a field experience has the potential to bring these concepts to life by showing, for example, that fossils can be found hear home, and that by learning about them we can learn much about our own environment and how it has changed.

The national parks and monuments and public lands can play an important part in bringing paleontology into the lives of children. Fossil resources of National Park Service (NPS) units are protected but available to all the public, through all types of exhibits. Furthermore, NPS staffs are knowledgeable of the resources under their protection and are willing to tell school groups about them. Many national park units with fossil resources have visitor centers with museums and interpretive trails that are well suited to educational experiences. The Bureau of Land Management (BLM) administers about 270 million acres of public lands in 11 western states. Many areas on these lands could be used as outdoor paleontology laboratories and classrooms. Although a permit is required to collect vertebrate fossils, teachers and students may collect common invertebrate and plant fossils for classroom use on the public lands.

A study of paleontology in the classroom will benefit immensely from a visit to a national park or monument, or the public lands. We encourage teachers to take advantage of these resources, which offer a personal classroom for informal learning. Appendix A lists national park units that have important fossil resources. Included in this list are some of the facilities of the parks that might be of special interest to school groups. Appendix B lists areas on the public lands where there are interpretive exhibits on paleontology, and BLM State Offices where information on additional lands can be obtained.

Organization and philosophy

This guide is organized into four units: Unit 1, fossilization and human influences, for the second grade; and Unit 2, adaptation, Unit 3, community, and Unit 4, human influences, each for the third grade. These units are best presented in the sequence given, since each assumes a certain background covered by previous units. However, this background material could be presented separately without too much difficulty. The exercises in each unit can be done in the order and manner presented or separately, as part of a fossil curriculum designed by the teacher

A vocabulary list follows a short summary introduction to each unit. Understanding of most of these terms is necessary for complete comprehension of the lesson material. In some cases the teacher may find it necessary to discuss in detail the concepts behind these terms. The text following the vocabulary lists contains discussions of those concepts. Teachers may want to consult other reference materials. A list of references for teachers and students to help in understanding and expanding on the material present is given at the end of each unit.

The pre- and post-questions are intended for classroom discussion. If a test or written exercise is desired, the teacher could prepare one using these questions as a guide. All questions are repeated in Appendix E as classroom handout sheets.

The exercises are intended to be hands-on. Children are naturally motivated by objects and benefit from tangible examples, especially if they are allowed to manipulate them. Paleontologists also are typically object-oriented people who follow a hands-on approach to their work. In this way the exercises are realistic. However, rather than actual specimens, this kit includes casts of real fossils for several reasons. Hands-on use in the classroom places specimens in danger of damage or loss. Fossils are non-renewable natural resources, most of them irreplaceable. Fossil plants and invertebrates are typically more abundant, but vertebrate fossils, especially, are rare and valuable. Because of the quality of molding and casting processes today, casts not only have the advantage of durability and replaceability_ but also of very accurate replication of fossil material. In fact, many modern museum displays of fossil vertebrates are constructed entirely of casts.

Beyond science

We hope that this guide will help teachers go beyond teaching paleontology as "science" and introduce paleontological themes into other areas of study. For example, connections to the visual arts could be explored by having the class paint or sculpt scenes from the past imagined through their studies of fossils (see Activity 4 and Activity 9, Variation 1). A classroom activity such as Activity 15 (a . food web) could be done as a performance. The class could learn a poem or song about fossils. Learning about geologic time could also be used as an introduction to large numbers in a mathematics unit.

The planning chart in Appendix E stresses the different subjects that the theme of paleontology can enhance. The first chart is filled in with suggested ways this could be done; the second is left blank so the teacher can make copies and experiment with various customized plans.

Field trips

Classroom lessons would be complemented by a field trip to a site of paleontological interest. Pre-site activities are best done before the field trip, post-site activities after it. We encourage teachers to take advantage of the staffs of nearby NPS units or local BLM offices to help them in planning field trips. These staffs will also be helpful for advice if, for example, controversial situations arise in teaching paleontology in the classroom.

A teacher does not need to be an expert in paleontology or geology to lead a good field trip for children. He or she need only have a basic knowledge of the age of the rocks and types of environments and fossils that are present in the area to be visited. This information can be gotten from the staffs of museums, parks, or geology departments. Many parks and monuments have special programs available for school groups. These programs may include ranger-led hikes, speciallydesigned activities with fossil themes, Junior Ranger programs, and fossil demonstrations. In many cases, a ranger will visit the classroom.

We recommend that you call the park you intend to visit well in advance of a planned field trip. Early scheduling will give you a better chance of getting the desired date. Spring and fall are popular times for visits to parks and monuments. When scheduling a visit, be sure to let the rangers know what you have been studying. There may be special activities in which your students can participate.

While this guide was developed for use in conjunction with a trip to a national park or monument, teachers without easy access to an NPS unit will often be able to find other sites where fossils may be found, such as mines, quarries, or gravel pits, or on the public lands. Consult with your local BLM office or your state geological survey for the location of geologically and paleontologically significant areas nearby. Geologists and paleontologists at nearby natural history museums can also provide information and may even help you plan a field trip. The appendices list addresses and phone numbers for geological surveys and many museums.

The advantages of seeing rocks and fossils in the field cannot be overstressed. Specimens and photographs will help students recognize certain fossils and visualize ancient environments, but actually seeing, touching, and possibly even collecting, a fossil in place communicates a far stronger message. A field trip allows the student to visit the actual site where the fossil organism lived and died. It allows him or her to see the actual sediments, now turned to rock, that entombed it. And the person who finds a fossil is often the first human ever to see this object Students will soon find that they can make original and noteworthy discoveries in paleontology.

Ideally, lessons taught on field trips should complement the emphasis of the current teaching unit, but should not be restricted by it if other interesting topics present themselves. For a field trip to be most effective, considerable time should be spent in the classroom preparing the students for what they will see and do in the field. This should include some geography, placing the trip destination in a regional and national context. Rudimentary geologic history should also be covered. This might include a simple stratigraphic column like the one in Appendix E. Students could color in the different rock units and illustrate their diagrams with fossils found in each unit. Discussion of geologic history should include, as a minimum, talking about the types of animals and plants that were living at the time the rocks of the field site were being deposited. Appendix D (geologic time scale) provides some basic geologic information. If you are planning a visit to a national park or monument, park staff or publications available from the park may be able to provide additional background material.

Besides helping students learn about the importance of fossils, a field trip gives teachers the opportunity to make some other important points about the students' influence on science and society. By properly recording information about any fossils they end, students will assure that others will have access to this same information in the future. It is also important to report finds to experts, and to learn as much as possible about fossils in order to recognize a find that is rare or exceptionally important.

Proper field etiquette should be discussed in the classroom. On private land, stress that trespassing is not only bad manners but also illegal. Tell the students that you have talked with the landowner and he/she has given permission for the class to be there. In national parks and monuments, digging or collecting fossils is . not allowed without a scientific permit. On other federal land, collectors need permits for certain kinds of fossils.

Many national parks and monuments act as scientific laboratories where paleontologists collect and study fossils. The information gathered is sometimes presented to park visitors in educational programs developed especially for them. Fossils on these lands belong to all people and are being protected and preserved for all generations.

• Planning a field trip A valuable .activity for the class could be to participate in the planning of a field trip by putting together a list of gear to bring along. Important items include clothing appropriate for the site and weather, a camera, notebook and pencils, water, and a lunch. Roc hammers, chisels, and collecting bags may be useful for a trip to a privately-owned site or lands administered by the BLM, but are forbidden in national parks. Be sure you get permission ahead of time from all landowners to enter or collect on private land. Land ownership can be researched using maps available at local BLM offices or other land management agencies. Maps are essential for determining the location of finds, and can help students learn how to get around in the field.

• Safety . The importance of safety in the field should be discussed prior to and during any excursion. If you are visiting a roadcut, please be extremely cautious, as traffic can make roadside outcrops very dangerous places to visit. Be extremely careful, both for yourself and others below you, when climbing around on loose rock. Watch out for poisonous snakes that may be found in rocky areas. Be sure to carry plenty of water, wear a hat, and have other protection from the sun.

• Paleontology on a budget We realize that many schools are not able to take their students on field trips because of budget constraints. Many national parks and monuments, as well as some museums, have slide or video programs that they will loan to schools. These cannot take the place of an actual field trip, but may be the next best thing for those unable to travel.

A learning log

The ability to write clearly is among the most important skills that scientists, including paleontologists, need. Learning about the natural world is fun, but of limited use if you cannot communicate your results to the rest of the world. Children in the second and third grades are beginning to learn how to express themselves in writing. Learning about paleontology provides many opportunities for practicing written communication. Have the students start a personal "learning log" at the beginning of their paleontology study. Each day, set aside some time for them to write about their experiences for that day. They could also include drawings and other visual aids. When their studies are finished, their learning log, along with other materials accumulated, will document a set of pleasant experiences in paleontology.

Contents

Kit contents checklist

1. One plaster cast: Leaf, *Ptychocarpus* sp., Pennsylvanian, Illinois
2. One plaster cast: Brachiopod, wide-hinged spirifer, Pennsylvanian, Utah
3. Two plaster casts: Gastropod (snail), high-spiced shell, Tertiary
   Gastropods, *Goniobasis* sp., Eocene, Wyoming
4. One plaster cast: Crinoid, columnals (stem segments) of "sea lily," Paleozoic
5. One plaster cast: Shark tooth, *Otodus* sp., Miocene, Morocco
6. Two plaster casts: Fish, Green River Formation, Eocene, western Wyoming
7. One plaster cast: Dinosaur skin, found with bones of duckbill dinosaur, Cretaceous, Alberta, Canada
8. One plaster cast: Trilobite, *Phacops rana*, Devonian, Ohio
9. One plaster cast: (blue sticker) Lower jaw of fossil carnivore, *Thinocyon velox*, Eocene, western Wyoming
10. One plaster cast: Crinoid, Unidentified crinoid, Mississippian, Kansas
11. One plaster cast: Lower jaw of fossil omnivore (black sticker)
12. One plaster cast: (green sticker) Lower jaw of fossil herbivore, tapir, *Isectolbphus* sp., Eocene, Wyoming
13. One plaster cast: Lower jaw of coyote, modern carnivore/omnivore (yellow sticker)
14. One plaster cast: Lower jaw of rabbit, modern herbivore (orange sticker)
15. Plaster cast: plastic fish for fossilization activity, Unit 1
16. One slab: rock from Green River Formation, western Wyoming
17. Plastic cast: Fish and rock from Green River formation for preparation activity
18. One bag each: Plaster of Paris, modeling clay for teacher's use
19. One metal plate: Fossil rubbing
20. 25 magnifying lenses
21. One Poster: Geologic Time
22. One Map: National Parks and Monuments
23. Eight brochures: Fossil Parks in the National Park System
24. Three Brochures: A Guide to Fossil Parks, Fossil Collecting Issues, Fossil Collecting on Public Lands
25. Slide carousel: Introduction to fossils, Unit 1 (60 slides)
26. Slide carousel: Environments and adaptations, Unit 2 (34 slides)
27. Three discs: computer simulation, Unit 3
28. One video: Fossil Lake

UNIT ONE: FOSSILIZATION

Introduction

How does a living thing become a fossil? The mysterious processes by which evidence of past life is preserved are explored in this unit. By thinking about and participating in some simulated sedimentary processes, children will be able to remove much of the mystery behind fossils and fossilization. More than 60 parks and monuments of the National Park System contain significant fossil deposits. A strong understanding of fossilization processes will prepare students for a field visit to a fossil park or other fossil area on public lands.

This unit introduces the concept that fossils are remains or traces of ancient living things by giving students the opportunity to create their own "fossils." By studying some of the different ways that organisms can leave a fossil record (actual remains, impressions, footprints, natural casts and molds), students will be encouraged to think of other ways this can happen. They may also begin to think about how rare an event fossilization is. The concept of human influences is introduced by having the students play the roles of finders, collectors, and interpreters of fossils.

Objectives

After completing this unit students will be able to:

1) evaluate the importance of fossils to our knowledge of life;

2) identify conditions necessary for fossilization;

3) construct a possible scenario for formation of a fossil; and

4) devise a code of behavior based on ethical behavior for student paleontologists.

Materials included in the kit

slide carousel: introduction to fossils
plastic fish
plaster of Paris modeling clay

Optional materials

sheets of paper (newspaper is best; construction paper might not work)
X-acto or linoleum knife large,
shallow tray or plastic sheet shells,
leaves, or other potential "fossils" collected by the class
fine sand
mud of two different colors
small trays or pie plates
plastic spoons and knives or popsicle sticks
heavy-duty aluminum foil

VOCABULARY

Coprolite (ko-pro-lite) Fossil dung.

Fossil Any evidence of past life.

Fossilization The processes that occur when evidence of past life is preserved. Not the same as mineralization or conversion to rock.

Natural resource A naturally-occurring material that is useful to society.\

Paleontologist (pay-lee-on-toPo-jist) A person whose job is the study of fossils and ancient life.

Scavenger An animal that eats animals that are already dead.

Sediment Naturally-occurring material transported and deposited by water or wind, such as mud, sand, peat.

Sedimentary rock A rock made of tightly packed and cemented sediment.

Trace fossil Evidence of an activity of a living thing. Examples: footprint, coprolite.

Overview

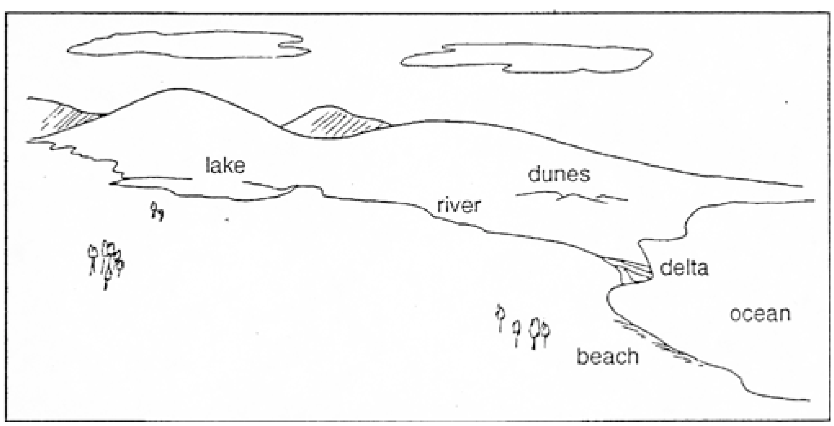
Definition of a fossil

A fossil can be defined as any naturally-occurring evidence of past life. Fossils need not be mineralized (turned to rock) or even enclosed in rock. Many relatively young (10,000 years old or more) Ice Age sedimentary deposits are uncemented sand and gravel, but rich with true fossils. Ice Age mammoths that have been found preserved in permafrost are fossils, although their flesh is still mostly undecayed. Ten thousand years is a lower limit often used for the age of organic remains that are considered fossils.

There are three basic types of rocks: sedimentary, metamorphic, and igneous. A field guide such as the Audubon Society Field Guide to Rocks and Minerals or an introductory geology textbook will discuss origins and help you identify rocks. With few exceptions, fossils occur in sediments or sedimentary rocks. Occasionally living things are preserved in lava flows or volcanic tuff deposits (igneous rocks), but these are relatively rare. Some metamorphic rocks (rocks changed by heat and pressure) contain fossils, but usually metamorphism destroys fossil details.

Sedimentation and fossilization

The fossilization process is intimately connected with sedimentary processes. Thus, environments where sediments are being deposited (depositional settings) are places where plants and animals have the potential to be fossilized. Examples of depositional environments include a lake bottom, a river sandbar, a beach, ocean floor, or dune field (see figure at right). Sediments originate from a variety of different sources. Some sediments result from the breakdown, through weathering, of pre-existing rocks; these are called clastic sediments. Common clastic sediments are sand, gravel, silt, clay, and mud. The sedimentary rocks they turn into are sandstone, conglomerate, siltstone, claystone, and mudstone, respectively.



(Some places where seidments could be deposited – depositional settings)

Organic sediments originate as tissues of plants or animals. Leaf litter on a forest floor is an example of organic sediment. Much sand and mud in marine environments results from the breakdown of shells or skeletons of animals (oysters and corals, for example) and plants (marine algae). This sediment is rich in calcium carbonate and forms the rock limestone. The organic sediment peat, usually deposited in a swampy environment, becomes, with heat and pressure, the sedimentary rock coal.

Still other kinds of sediment are formed when certain chemicals in a body of water reach too high a concentration to remain in solution, and precipitate out. An example is the evaporation of seawater to form salt. Some limestones also form this way.

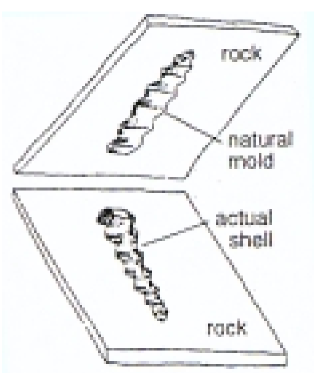
Regardless of the type of sediment or sedimentary environment in which an organism dies, fossilization is by no means guaranteed. There are a number of requirements that must be met before preservation of organic remains is assured. The difficulty of meeting all of these requirements is the reason that fossilization is a rare and chance occurrence. First, organisms that possess hard parts of some kind, such as bones, teeth or shells, stand a far better chance of fossilization than those that do not. Soft-bodied worms, for example, are extremely rare as fossils although they are common in marine and terrestrial settings. Absence of organisms with hard parts is the main reason that fossils from Precambrian time (see geologic time chart, Appendix D, page 77) are so rare.

The second requirement for fossilization is rapid burial in a protective medium. Upon death, the remains of most organisms are quickly acted on by scavengers and by microorganisms that promote decay. Physical action in the natural environment (e.g., currents, waves, wind, and rain) is also destructive. If the remains are to make it into the fossil record they must be buried quickly in an oxygen-free environment before these processes have a chance to destroy them. The type of sediment also affects the quality of fossil preservation; fine-grained sediments are more likely to favor the preservation of small details.

Examples of different kinds of fossilization

- Fish sinks to oxygen-free bottom of lake, buried in soft mud.
- Herd of animals drowns in flood, buried in river sand.
- Shell debris accumulates slowly on ocean floor
- Animals grazing on plains buried by sudden eruption of volcanic ash

Conditions after burial are also important in aiding or hindering preservation of organic remains. This stage in the process, the third requirement for fossilization, is called diagenesis. Diagenesis refers to everything that happens to a sediment after it is deposited. The effects of pressure, heat, and circulating fluids that in time turn a sediment into a sedimentary rock also act on the organic contents of the sediment, altering their composition and appearance. Sometimes a potential fossil maybe dissolved in the process of diagenesis. Other times it may become mineralized. Think of how hard water acts in a teapot or in water pipes over time; deposition of minerals in those places is similar to the mineralization process that cements sediments into rock. Mineralization (or petrification), in which a fossil effectively "turns to stone," may help preserve a fossil, but is not a requirement for fossilization. Many organic remains can be preserved essentially unaltered for millions of years and still be true fossils.



A fossil snail and its natural mold in the rock.

Not all fossils are actual remains of living things. Sometimes only an impression of the animal or plant is left behind after its death, such as a natural mold of a shell.

A good introduction to fossils is presented in the slide program "Introduction to Fossils" included in the kit. A useful exercise in discussing fossilization is the handout "The story of how a rabbit became a fossil," in Appendix E, pages 78-79.

Trace fossils

A trace fossil is evidence of some activity or behavior of an animal or plant while the organism was still alive. Some examples of trace fossils are footprints and trackways, burrows, coprolites, and root casts. Ancient ripple marks, mud cracks, or raindrops preserved in rock are called "sedimentary structures," but because they do not represent activities of living things, they are not trace fossils. Because actual remains of the organism that made a trace fossil are usually not preserved, the trace maker is often unknown. Trace fossils are nevertheless strong and valuable evidence that certain kinds of activities occurred in a given environment. They are useful in learning about the types of animals and their interactions in ancient environments.

A trace fossil: bird tracks in lake sediments.

Fossils as nonrenewable natural resources

Fossils of all kinds are the only direct evidence we have of past life. As such they are irreplaceable natural resources for science. It is important for students to understand that fossils should be used wisely, and that they can participate in their conservation. Private collecting of fossils is basically a good thing; amateur paleontologists can collect valuable information. But amateurs should always follow standards of professional ethics, including discussing their finds with experts in a position to recognise exceptional or valuable specimens. Good field records are necessary so that all finds can be exactly relocated. In addition, it is important for children to learn to respect public and private lands by not trespassing and by obtaining permission to dig or collect specimens.

Protection of fossil resources is aided by public facilities such as the National Park System and on lands administered by other federal agencies. In the national parks and monuments, fossils are protected from destruction and made available for educational and scientific use by the public.

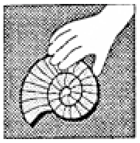
Pre-questions

1. What is a fossil? Refer to the definition in the vocabulary list

2. How does an animal or plant become a fossil? Use this question at the beginning to see how much the students know about fossils. The overview discussion describes three things that are usually necessary for an organism to become a fossil: hard parts, quick burial, and favorable conditions after burial (diagenesis).

3. Your footprints on the beach are evidence that you were there. Do you think you could call your footprints trace fossils? Why or why not? If they were still there after 20,000 years, could you call them fossils then? Footprints are examples of trace fossils. Most paleontologists would agree that remains or traces of any kind should be more than about 10,000 years old before they can be called true fossils.

ACTIVITY 1 One way a living thing could become a fossil



Message Fossils are remains or indirect evidence of past life. Plants and animals become fossils only under certain conditions.

Version 1-wet paper as sediment

I. Materials Sheets of white and colored paper of uniform size (newspaper works best); plastic fish skeleton; shallow tray, cake pan, or plastic sheet; water, sharp knife (like a linoleum knife); other simulated fossils.

II. Procedure

1. **Lay down paper "sediment."** do this exercise on the floor on a sheet of plastic or in a large, shallow tray. Wet the sheets of paper one by one and place several on top of each other on the plastic sheet or tray. Tell the students that the sheets of wet paper represent layers of sediment (mud, sand, etc.) being deposited over a period of many years in a lake. The students can participate by wetting the sheets and lining them up one atop the other. It is not necessary for the sheets to be wrinkle-free or perfectly lined up.

2. **Add the fish.** After several sheets (say, 10 to 20) have been placed, ask a student to place the plastic fish on the center of the "sedimentary pile." Emphasize that the fish recently died and has sunk to the bottom of the lake where these sediments are accumulating. The students may have other objects such as leaves, shells, or bones, that they can place between the "sediment' layers as they accumulate. This will make the exercise more interesting and will allow the direct participation of a larger number of children.

3. What happens next? After the fish is in place, discuss possible fates of this skeleton. Remember, the fish is not yet assured of becoming a fossil. Have the students think of some things that could happen to this skeleton that would prevent it from becoming a fossil. Possibilities: It could be eaten by a *scavenger.* It could decay. It could be washed away by currents. If and when the class decides that in this case the skeleton will not be destroyed and will have the opportunity to fossilize, you may proceed with more wetpaper sediment.

4. **Let the "sediment" turn into "rock."** When the pile of paper and potential "fossils" is an inch or so thick, stop the "sedimentation" and allow the pile to dry. This may take several days, depending on the conditions. Explain to the students that in reality, deposition of an inch of sediment may take many thousands of years, and it may be still more thousands or even millions of years before the sediment has a chance to turn into sedimentary rock. The drying of the paper serves as a simulation of turning sediment to sedimentary rock.

5. Excavate the "fossils." When the paper pile is dry, proceed with "discovery" and "excavation" of the fossils it contains. Begin by cutting away paper from the top of the stack. A sharp knife may be necessary for this, so it may be best to limit the students' participation in this part of the exercise. Explain that since the top layers were deposited last, they represent the youngest rocks, and as you go deeper into earlier-deposited layers, you find older and older rocks and fossils. Keep track of the kinds of fossils you collect from each layer.

This exercise may be extended by organizing the fossils excavated from the paper. Have the students put fossils collected from the same layers together, as they represent fossils of the same age. Refer to the handout "Stratigraphy" in Appendix E (page 94) for ideas on recording stratigraphic positions of the fossils the class collects.

Version 2-paper cups with mud

Materials Paper cups, one for each student or working group; mud of two contrasting colors; bones, shells, leaves, or other possible "fossils;" spoons.

This version is somewhat more realistic than version one in that actual sediment is used. It also has the advantage that each student could have his or her own specimen. It may, however, take a little longer and be more difficult to set up and monitor.

Procedure

1. Add layers of mud to the "lake." Distribute a paper cup to each student, or to each group if they will be working cooperatively. Explain that they are going to simulate a lake in which mud is slowly being deposited. In this lake live plants and animals that fall to the bottom when they die. Add liquid mud to the cup in increments, alternating colors and allowing the mud to settle between each addition. The students may add small shells, leaves, or bones at any point in the sedimentation process.

2. Dry the sediment. The drying of the mud simulates turning the sediment into rock. Drying will take place much faster if the cups are placed in a warm, dry place, even a warm oven, for a few hours. If the mud is fairly soft when dry, the students can excavate their own "fossils.",

Variation Make a small pond in the schoolyard and fill it with muddy water over a period of days. To this sedimentary system have the students add chicken bones brought from home (ask them to remove all traces of meat from the bones and scrub them with soap before bringing them to class). When the pond is full of sediment, let it dry out, and excavate the "fossils." Be sure to keep up the message that geological time is very long and this is only a simulation.

ACTIVITY 2 Making a trace fossil

Message A trace fossil is evidence of activity of a plant or animal. Trace fossils are useful for learning about ancient life.

Materials Shallow trays or pie plates; fine sand or modeling clay; plaster of Paris; carving tools (plastic knives and spoons, popsicle sticks).

Begin by reading the discussion of trace fossils on page 5. When you explain this exercise to the students, it is important to bear in mind the difference between a trace fossil and a mere impression made in sediment by a dead organism. A trace fossil is evidence of the activity of a living organism. Often trace fossils provide valuable information about how an animal lived and interacted with its environment. Sometimes it is not clear which animal was responsible for a given trace fossil.

Procedure '

1. **Create a depositional setting.** The depositional setting is represented in this activity by a shallow tray or pie plate containing a layer of clay or fine, damp sand. If you use sand, it should be fine-grained and cohesive enough (a little clayey) so that it will hold details and not absorb too much plaster. The students can use their imaginations to decide what kind of environment their sand or clay surface represents. This might include a sea or lake bottom, beach, river, or sand dune.

2. **Choose an activity to "fossilize."** The students can use their imaginations to decide what kind of activity their trace fossil will preserve. Ask them to pretend that they are some kind of animal living in their chosen setting, and to think about what that animal might do that would leave a trace in the sand. The student may decide to carve a walking or crawling trace across the surface, or make a shallow burrow (depending on the thickness of the sand layer). Some animals, like earthworms and many different marine animals, even some whales, ingest sediment as they make their way through it, leaving a "feeding trace." The students' trays could be scale models, allowing them to represent a great variety of activities.

3. **Preserve the "trace fossils."** This can be done by pouring a layer of plaster of Paris over the clay or sand. This mimics the natural processes of burial by more sediment and turning to rock. After the plaster hardens, simulating the passage of perhaps millions of years during which the sediment turns to rock, the plaster can be removed. Tell the students that a trace fossil usually has two parts, the bottom part (the clay or sand) and the top part (plaster), the latter in this case being the better preserved. To reinforce the message, have each student prepare a label for his or her trace fossil, giving the name of the suspected trace maker and what activity is represented. Students may exchange the trace fossils and try to create in their minds the activities represented by their classmates' traces.

Variation 1 Look for potential trace fossils in the schoolyard. These might be tracks of people or pets, or even cars, in mud. The students could make plaster casts of these and display them along with an explanation. What kind of activities do these represent? What would have to happen to these tracks for them to become real fossils? If you discovered a trace fossil like this in a rock how would you interpret it?

Variation 2 Another variation on this exercise allows the students to be a little more systematic in their detective work. Have the students clear off an area of bare dirt or playground sand in the schoolyard with rakes or brooms so that no tracks are visible. Return the next day and take notes on what can be seen on that spot. What has happened here in the past 24 hours?

ACTIVITY 3 Replicating fossils with aluminum foil

Materials Two-dimensional fossils or casts; heavy-duty aluminum foil.

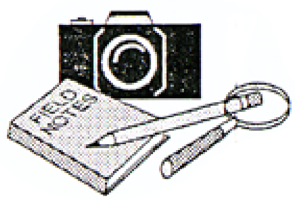
This is a simple way for students to make copies of certain fossils. It works best for specimens (or casts) that are reliefs on flat slabs of rock. It will not work with three-dimensional fossils unless only small parts of them are replicated. Specimens in the kit that are suitable for replication using this method are the fish impression, fossil leaf, and dinosaur skin impression.

Procedure

1. **Press fossil details into foil square.** Cut out a piece of heavy-duty aluminum foil slightly larger than the fossil to be replicated. Then press the foil in place over the fossil, molding it into its contours. For specimens with high relief some wrinkling of the foil is inevitable.

2. Trim the **foil replica.** After details are pressed into place, remove the foil and trim off any uneven edges with scissors. For permanence, the foil replica can be glued to a square of cardboard.

3. Complete the specimen. Fill out a label giving the fossil's name, age, and name of the place where it was found.



Field Trip

A first paleontological outing

This field trip is an introduction to paleontology. It may be the first time many of the students have thought about fossils and the rocks in which they are found. Material that is presented is limited only by the imagination and experience of the teacher. Since lesson material for this exercise is generalized, detailed information presented to the class will be determined by the field area visited. The perfect site for a field trip is a known fossil locality. If you are near a national or state park or area of public land, contact their office and ask them about the suitability of their area. Don't overlook places like quarries or gravel pits as possible sites. If these are not feasible consider the alternate field trip below.

Most of the time in the field could be spent looking at examples of fossils and , how they are found, and discussing how these organisms lived and became fossilized. A considerable amount of time will be taken up by students' questions. If they are allowed to collect fossils, the teacher or someone nearby should be knowledgeable to answer questions about the identity of their finds. With a little practice, fossil guidebooks (see references at end of each unit) will help teachers and students identify fossil finds.

One topic of this trip might be the origin of sedimentary rocks, whether or not they contain visible fossils. Seeing rocks in the field is a good way to visualize how sediments are deposited. Turning of sediments to rock over millions of years is a more difficult concept for children to grasp, but after seeing and touching the evidence, students can more easily accept these statements as observable facts. In the field, it is also easier to understand the concept of superposition: sedimentary rocks on top are younger than rocks beneath them. Students then have the basics of relative dating using fossils.

• **Ethics in the field** It is a good idea to bring up the topic of ethics in paleontology on the students' very first encounter with fossils. There is no better place to do this than on their first field trip. Good ethics (for professionals and students alike) encompasses such things as asking permission to explore or collect on public or private land and not disturbing that land any more than necessary. It also means taking careful field notes and properly recording the location of each find for further reference. It is also advisable to learn as much as you can about the fossils you find by reading and talking to experts in the area so that you know the difference between common fossils and rare ones.

• **An alternate field trip** A trip to a local park, river, lake, or seashore could become a study in fossilization. Some questions that you might be able to address on hiking with the students include: What kind of depositional settings are found here? Where is. sediment being deposited and what kind of sediment is it? What kind of animals and plants live here? How many of them have a chance of being preserved as fossils? Do all of them stand equal chances? What would be some ways fossils could be preserved in these settings?

Post-questions

1. **What are some ways that an animal or plant could become a fossil? (Name as many different ways as you can think of.)** *See the box on page 4 for some ways organisms can become fossils.*

2. **What three things are required for a living thing to become a fossil?**
See the Overview discussion. The three things that are required are, 1 possession of hard parts, 2 quick burial in a protective environment, and 3 favorable conditions after burial (diagenesis).

3. **Why is it normally so difficult for a plant or animal to become a fossil after it dies?** *The chances are small that all the conditions will be just right. Not many places have the right combination of depositional setting and possibility of preservation after burial.*

4. **What is the difference between a "normal" fossil (body fossil) and a trace fossil?** *A body fossil is actual remains of hard parts of a plant or animal. A trace fossil is evidence of activity of a living thing-no actual remains are necessary.*

5. **Why are fossils important? What do they tell** *us? Fossils are important because they show us what living things were like before there were people around to record them. They tell us many things: what these organisms looked like, what they ate, where they lived, how they interacted. They allow us to piece together the history of life.*

6. **Parts of a living thing may be preserved for millions of years in rock. These fossils provide very important evidence of how living things were different in the past. They can never be replaced or destroyed. What can you do to protect this valuable evidence?** *See the Overview discussion in this unit and in Unit 4, Human Influences. Students and amateur fossil collectors can help conserve fossil resources by reporting finds to professionals in parks, museums and universities.*

7. **Name some national parks or monuments or sites on public land that have fossils. What kind of fossils are they?** *See the list of national parks and monuments with fossils in Appendix A, page 68, and the list of sites on public land, Appendix 8, page 73.*

Post-site activities

ACTIVITY 4 The fossilization game

Message It is not easy to become a fossil. Many plants and animals never have the chance to be preserved as fossils.

Materials You may make copies of the fossilization cards in Appendix E (page 92) or have the class design their own.

The fossilization game is a fantasy and role-playing exercise that helps children understand fossilization processes.

Procedure

1. **Choose an environment.** The game begins with the class or smaller group choosing an environment in which there is a depositional setting such as a lake, pond, stream, river in a forest, sea floor. The students can use their imaginations to describe this setting in as much detail as they desire.

2. Choose roles. Roles that the participants choose for themselves are possible animal or plant inhabitants of the chosen setting. For example, in the aquatic settings possible roles include not only snails, clams, fish, salamanders, turtles, alligators, and other aquatic animals, but also horses, deer, monkeys, rabbits, and birds that come there to drink.

3. **Begin play.** When play begins, the children act out their roles, with each one given a turn to make vocalizations or gestures. For example, a child playing a fish could wiggle his body with a fishlike motion and make gulping motions with his mouth. A child playing a prairie dog might pretend to dig a burrow and make high-pitched barks. They can also interact with each other as they would in their natural environment. For example, the carnivores could chase the herbivores.

4. **"Freeze" and decide the fate of the characters.** At a time determined by the teacher, action "freezes" and the time for possible fossilization begins. The students draw cards which tell their fate: *You are eaten by scavengers. You rot away before you can be preserved. You are swallowed by a crocodile. You are buried by a mudslide and preserved as a fossil.* You can make several copies of the page of cards in Appendix E to use in this exercise. If you make your own, the proportion of "fossilization" cards to "destruction" cards should be small, mimicking the small chance of becoming fossilized in the real world.

5. **Discuss the meaning of this exercise.** When the entire class has drawn cards, discussion can begin. Have each student discuss his or her role as an organism and what happened to this organism after it died. Make a .list of these organisms on the blackboard. Which animals became fossils? Which were destroyed? Remember, the only animals and plants future paleontologists will know anything about are the ones that become fossils. You will become aware of the important question of bias in the fossil record when you compare the list of fossils with the complete list of living animals. Is the list of fossils a good representation. of the living community? Why not?

If time allows, play the game again with the same animals and plants. How are the results similar or different?

ACTIVITY 5 Some parts make better fossils than others

Message — Not all parts of animals and plants become fossilized. It may not be possible to know some details of what an ancient animal or plant was like because many parts of the anatomy may not become fossils.

Materials — Drawings of horse and Stegosaurus skeletons (Appendix E, pages 93-94)

In carrying out the preceding exercises and discussing fossils in the classroom, it should have become evident that fossilization is a rare event. The chances of a given individual being preserved in the fossil record are very small. Some organisms, however, have better chances than others because of the composition of their skeletons or where they live. This also applies to the various parts of organisms. For example, plants and vertebrates (animals with bones) are made up of different parts that can separate after death. The different parts can be transported by currents to different locations and be preserved separately. A fossil toe bone might be found at one place and a fossil rib at another location. We could assume that they are from different animals when, in fact, they came from the same one.

Much information is lost in the fossilization process. Think, for example, of a vertebrate (such as ourselves). Much of what we consider important about our own biology is in the soft tissues, such as skin, hair and internal organs. These characteristics would usually be unknown in the fossil state, because most of the time only bones and teeth are preserved. (There are exceptional cases where soft parts are preserved.) Bones and teeth are not always preserved together. This exercise is designed to get children to think about the quality of information that comes from the fossil record.

Procedure

1. **List facts about a living animal.** The skeleton of a horse is shown in Appendix E, so a horse will be used as an example here. Other possibilities include a cow, dog, cat, or sheep. The list of facts on the horse might include, but not be limited to: large size, fast runner, eats grass, has grinding teeth, has long hair for a mane and tail, whinnies, is intelligent, is sociable %vith other horses, makes a good pet.

2. **What would we know if this animal was extinct?** Refer to the diagram and point out an important generality of fossilization: most of the time, only the hard parts (bones and teeth) are preserved as fossils. Go through the list and ask the class what we would know about the horse if horses were extinct and all we had were fossilized bones of horses. We would know that it was a large animal and could probably make some good guesses about its weight. We would know that it had grinding teeth and could probably guess from that that it ate some sort of tough vegetation, probably grass. The hooves would not be preserved, but the shape of the foot bones would be a good indicator that it had hooves. The skeleton would also be useful to tell us that it was a fast runner. But no details of the hair or skin would be known. Everything about social behavior or vocalization would also have to be guesses.

3. **What do we know about fossils?** Pass out the diagram of the fossil Stegosaurus and interpret it in the light of what we do not know. Use the list you made in discussing the living animal. What paleontologists know comes from studying the hard anatomy, in this case bones and teeth. Anything else is a guess, although in most cases it is possible to base the guess on sound biological principles.

4. **Use your imagination!** As a summary to this exercise, have the class put muscles and skin on the diagram of Stegosaurus that they have. Remember, hair, scales, and skin color are largely the choice of the artist, since fossil bones are no help.

ACTIVITY 6
A classroom museum

A classroom museum can be modeled after Activity 18, A classroom natural history museum, in Unit 4 (pages 56-57). Encourage your students to bring in fossils they or their parents have found. Along with objects created in class, the class may develop quite a collection of fossils and simulated fossils. Gather these objects together for your small natural history museum. Displays or exhibits can be designed and set up by the students. Specimens should be complete with labels giving their name and where they were found. Suitable museum labels can be found as a handout page (page 99) in Appendix E. Pictures of fossils rather than names could be used. Have the students write stories describing their experiences collecting and interpreting the fossils in the museum collection. Fossils could be used for further discussions about what scientists know about the original organism. If enough fossils are brought in, locations of finds could be plotted on a state road map or a map obtained from a local BLM office.

National Parks and Monuments and Public Lands

Fossilization in action

One place where thousands of animals and plants have been preserved as fossils (and are still being preserved today) is Rancho La Brea in Los Angeles, California. Rancho La Brea is not a national park or monument, but it is recognized by the National Park Service as a National Natural Landmark because of its outstanding natural features.

Rancho La Brea is the site of a natural asphalt (tar) seep in which have been found the bones of thousands of animals, as well plant remains. Most of the fossils at Rancho La Brea date from 40,000 to about 4,000 years ago. Over 420 species of animals and 140 species of plants have been found in the tar pits. Only one human fossil has been found: that of a woman who lived about 9,000 years ago.

The most popular explanation for formation of the Rancho La Brea fossil deposit is that animals became entrapped in sticky tar and were unable to extract themselves. Scavengers were attracted by the struggling animals and became entrapped themselves. After death, their flesh rotted away and their bones settled into the asphalt. During the wet season streams deposited sand over the asphalt pools and helped to bury the bones. Thus the three requirements for fossilization are met: hard parts, rapid burial, and suitable conditions after burial (diagenesis).

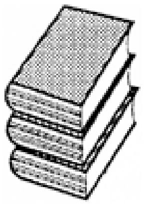
Today Rancho La Brea is a park where several small asphalt pools are visible. One pool is enclosed by a building with a viewing platform. There it is easy to imagine becoming trapped in the sticky tar and slowly sinking out of sight.

The George C. Page Museum, a branch of the Natural History Museum of Los Angeles County, was built on the site of Rancho La Brea to house and display the fossils collected from the asphalt. The museum and asphalt pits are located in Hancock Park in western Los Angeles.

See the book *Rancho La Brea: Treasures of the Tar Pits,* edited by John M. Harris and George T. Jefferson, Natural History Museum of Los Angeles County, distributed by University of Washington Press, 1985 (ISBN 0-938644-19-X).

• **Other Sites** Examples of many different kinds of fossilization can be seen in the national parks and monuments and on the public lands. At Florissant Fossil Beds National Monument, fossil plants, insects, fish, birds, and small mammals have been preserved in lake sediments. They were buried in the lake by ash spewed from volcanos about 30 million years ago. Some fossils at Florissant were buried quickly by mudflows triggered by volcanic eruptions. A lake was also the site of fossilization at Fossil Butte National Monument and surrounding public lands in Wyoming.

Floodplains of rivers are often good places for fossilization to occur. Animals may live on floodplains or visit there frequently because there is water available and often trees for shelter. Bones of animals that live on floodplains accumulate over a period of several years and then are buried in river silt by floods. In Petrified Forest National Park in Arizona, floodplain sediments preserve the fossils of dinosaurs and trees. Volcanic ash helped in quick burial of some of those remains. River channels and floodplains were the burial sites of the dinosaurs at Dinosaur National Monument in Utah. Rivers and floodplains were also responsible for preserving the many fossil mammals at Badlands National Park in South Dakota and at the Brown/Howe Dinosaur Quarry near Shell, Wyoming.



I Simon and Schuster's Guide to Fossils, P. Arduini and G. Teruzzi, Simon and I Schuster, 1987. (ISBN 0-671-63132-2) This book introduces paleontology and sedimentary geology for the amateur collector. Its many color pictures of fossils are among the most beautiful available in a book of this kind.

Evolution of the Earth, R.H. Dott and R.L. Batten, McGraw-Hill, 1981. (ISBN 0-07-017625-6) One of the best "standard" historical geology texts. Useful as a general reference, as well as interesting reading on the history of earth and life.

The Fossil Book: A Record of Prehistoric Life, C.L. Fenton and M.A. Fenton, Doubleday and Co., 1989. (No ISBN) A classic of paleontology, this book contains a wealth of information on most groups of fossil plants and animals, marine and terrestrial. The glossary and guide for amateur fossil collectors are valuable accompaniments to the text.

The Field Guide to Prehistoric Life, David Lambert, Facts on File, 1985. (ISBN 0-8160-1125-7) This "concise key to prehistoric animals, plants, and other organisms" is a reference to many different groups of fossils, geologic periods, principles, practices, and accomplishments of paleontology. Its unusual field-guide format, using text and picture boxes, lends itself to browsing.

Fossils: How to Find and Identify over 300 Genera, R. Moody, Collier Books, MacMillan Publishing Co., 1986. (ISBN 0-02-063370-X) A concise introduction to paleontology for a person who wants to look for fossils in the field. Discusses preparation, safety, and proper conduct. Background material addresses modes of fossilization. Color photographs and accompanying descriptive text would be helpful in identification of fossils.

Fossils: A Golden Guide, Rhodes, Zim, and Schaffer, Golden Press, 1962. (ISBN 0-307-24411-3) An illustrated guide for the amateur, especially suited as a first fossil book for children. Shows some of the more common invertebrate and vertebrate fossils.

Geology: The Active Earth, Ranger Rick's NatureScope, National Wildlife Federation, 1988. (ISBN 0-945051-38-7) A good reference for teachers. This book examines how and when fossils form, what they tell about the past, how scientists determine the ages of fossils, origins and uses of rocks, minerals, and fossil fuels, forces that wear down landforms and forces that build them up, and an introduction to plate tectonics. Good classroom activities.

The Illustrated Encyclopedia of Fossils, G. Pinna, Facts on File, 1990. (ISBN 0-8160-2149-X) A lavishly illustrated book displaying a diversity of fossil plants, vertebrates, and invertebrates. Presents a good discussion of fossilization processes.

The Encyclopedia of Prehistoric Life, R. Steel and A. P. Harvey, McGraw-Hill, 1979. (ISBN 0-07-060920-9) A comprehensive summary of fossil organisms, evolution, principles, techniques, and history of paleontology. This book is a useful, semi-technical reference for amateur and professional paleontologists.

Understanding and Collecting Rocks and Fossils, Martyn Bromwell, Usborne Publishing Ltd., 1983. (ISBN 0-86020-765-X) Introduces the amateur to identification of common rocks and minerals. Describes how to prepare for a field trip to collect rocks or fossils. Contains some aids for fossil identification. Introduces geologic mapping. A source of classroom activities in geology and paleontology. Interesting reading for children or adults.

Project Wild Elementary Activity Guide, Western Regional Environmental Education Council, 1988. (No ISBN) A bonanza of classroom and field activities designed to increase awareness of wildlife and their habitat. Many exercises in this guide address themes of adaptation, community, and human influences and could be applied to a study of paleontology.

Exploring Science Through Literature, Level B, JoEllen Moore and Thomas Camille, Evan-Moor Corp., 1991. (No ISBN) Good activities regarding rocks.

Books for children

Digging into Dinosaurs, Ranger Rick's NatureScope, National Wildlife Federation, 1989: (ISBN 0-945051-33-6) A good reference for teachers. It has good background information and activities on dinosaurs and fossils. Among the activities are time line and fossilization exercises and discussion of meat- and plant-eating dinosaurs and modern animals.

The Fossil Factory, Niles, Douglas, and Gregory Eldredge, Addison Wesley Publishing Co., 1989. (ISBN 0-201-18599-7) This book contains good activities for children with fossils, fossilization processes, and collecting.

Fossils: A New True Book, Allan Roberts, Children's Press, 1983. (I S B N 0-516-41678-2) Introduces fossils to beginning readers in grades 1 through 3.

Fossils Tell of Long Ago, Aliki, Crowell, 1972. (ISBN 0-06-445093-7) Describes some of the ways living things can become fossils and tells a story of children's adventures with paleontology. May help children learn why fossils are important.

The Children's Picture Prehistory: Prehistoric Mammals, Our World After the Dinosaurs, Anne McCord, Usborne Publishing Ltd., 1977. (ISBN 0-86020-128-7) A well-illustrated discussion for children of several interesting aspects of fossil mammals. Some ideas for classroom activities. Contains an illustrated glossary.

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The How and Why Activity Wonder Book of Dinosaurs, Q.L. Pearce, Price Stearn Sloan, 1988. (ISBN 0-8431-4286-3) An easy-to-read introduction to dinosaurs and some other fossil groups. The text is enhanced with numerous puzzles and hands-on activities.

Video

Dinosaurs, Puzzles From the Past, No. 51046, National Geographic Society, Educational Video Presentations, Washington DC 20036. Excellent 20-minute video about the geological time line.